REMARKS

(A) STATUS OF THE APPLICATION

Applicants thank the Examiner for her explanation of the rejections in the Final Office Action dated December 20, 2005 and the Advisory Action dated February 27, 2005.

(I) DISPOSITION OF CLAIMS

(i) Claims 1, 3-6, 9 and 11 are pending in the application.

(ii) Claims 2, 7, 8 and 10 have been canceled.

(iii) Claims 1, 3, 9 and 11 are rejected under 35 U.S.C. § 102(e), or in the alternative, under 35 U.S.C. § 103(a).

(iv) Claims 4 and 5 and 6 are rejected under 35 U.S.C. § 103(a).

(II) APPLICANTS' ACTION

(i) Claim 1 has been amended (see page 8 of patent application disclosure, line 7 to 9 for support).

(ii) Applicants respond to the above rejections.

(B) RESPONSE TO REJECTION UNDER 35 U.S.C. § 102 (E) AND 35 U.S.C. 103(A)

Applicants respond to Examiner's rejection of claims in the present patent application, below.

(I) U.S. PATENT NO. 6,592,999 TO ANDERSON, *ET AL.*

Claims 1, 3, 9 and 11 have been rejected under 35 U.S.C. § 102(e) as anticipated by, or in the alternative, under 35 U.S.C. § 103(a) as obvious over U.S. Patent 6,592,999 to Anderson, *et al.* (*hereinafter* "Anderson").

Applicants respectfully submit that Claims 1, 3, 9 and 11 are not anticipated by Anderson. Specifically, Applicants' method is directed to the refinishing of multi-coated substrates. In the Office Action dated July 26, 2005 (to which the Examiner refers to in the present Office Action), on page 4, first full paragraph, the Examiner states that "[c]learly, all three-layer coatings can be used for refinishing because of interlayer adhesion between any of the layers,. . ." However, Anderson does not

disclose, at any place, a multi-layer coating comprising a primer and/or a primer surfacer (filler), a first solvent-based basecoat, a second aqueous basecoat and a solvent-based or aqueous clearcoat.

In fact, Applicants' process requires the application of two basecoats whereas Anderson applies a primer and a basecoat.

The Examiner disagrees to this assertion (originally made in our response to the Office Action of July 26, 2005) with regards to Anderson, and states to the contrary that "Anderson teaches **expressly** that the process requires the application of **two** ***basecoats***. **Therefore, Applicants' statement that Applicants process requires the application of two basecoats whereas Anderson applies a primer and a basecoat is incorrect.**" (Emphasis in the original).

Applicants respectfully disagree to this construction offered by the Examiner. Anderson does not, either expressly or implicitly, teach a process that requires TWO basecoats. Applicants reiterate their assertion that Anderson applies a primer and ONE basecoat AND NOT TWO basecoats.

In fact, we reproduce the original wording the Examiner refers to from Anderson, below:

> "The test panels, pre-coated with an **electrocoat primer** commercially available from PPG Industries; Inc., as ED5000 were coated with a primer/surfacer and a basecoat by spray application to a film thickness of 1.1 mils (27.9 microns) and 0.6 mils (15.2 microns) respectively, with **gray solventborne primer** commercially available from Akzo-Nobel Corp., and a **waterborne silver basecoat**. . . available from Solutia. . ."
> "The basecoat panels were then flashed 10 minutes at 176° F. (80° C.) before electrostatically applying the **powder clearcoating compositions**..." (Emphasis added).

Clearly, the multilayer coating of Anderson comprises:

1. pre-coated electrocoat primer;
2. gray solvent-borne primer/surfacer from Akzo;
3. water-borne silver basecoat from Solutia; and
4. powder clearcoat.

Applicants respectfully point out that the mention of "basecoat" in the above paragraph, occurring twice, refers to the same layer. In the first instance, "basecoat" is mentioned to indicate that the basecoat was applied by spray application. In the

second instance, "basecoat" is mentioned to indicate that such a basecoat is water-borne and that such a basecoat was obtained from Solutia, Inc. Applicants respectfully submit that a reference to the term "basecoat" in the above paragraph, although made twice, does refer to only ONE basecoat that which is spray-applied, that which is water-borne, and that which is obtained from Solutia, Inc.

Furthermore, the gray solvent-borne primer can not be seen as a solvent-borne basecoat. To a person skilled in the pertinent art, a primer or a primer surfacer and a basecoat are two different elements, necessarily distinct serving different functions in the automotive finish related art (See discussion, *infra*).

Therefore, Applicants respectfully submit that Claims 1, 3, 9 and 11 are not anticipated under 35 U.S.C. § 102(e) by the Anderson reference.

Applicants respectfully disagree with the Examiner's reasoning of obviousness under 35 U.S.C. § 103(a) with reference to Anderson. Section 2142 of the MPEP indicates that a *prima facie* case of obviousness is established only when:

(1) all of the claim limitations are either taught, or suggested by the cited prior art;

(2) there is some suggestion or motivation to modify or combine the cited prior art references; AND

(3) there is a reasonable expectation of successfully producing the claimed invention via such a combination.

Section 2143 of the MPEP further explains that "[t]he teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not in applicant's disclosure."

Applicants respectfully assert that because neither of the three prongs set forth in the above test are satisfied, a *prima facie* case of obviousness is not established.

Particularly, as set forth in discussion *supra,* on anticipation under 35 U.S.C. § 102(e), it is clear that all of the claim limitations are neither taught nor suggested by the cited prior art, i.e., Anderson. Therefore, the first prong of the obviousness inquiry is not satisfied.

The present invention uses solvent- or water-based clearcoats instead of powder clearcoats as used in Anderson.

Further, the Examiner states that Anderson shows a method for forming multi-layer coatings that have improved interlayer adhesion. In the method of Anderson, on the primer-precoated substrate, a primer/surfacer and a gray solvent-borne primer are applied by spray application. A water-borne silver basecoat (claimed metallic effect pigment basecoat) is applied on said primer. A powdered clear coating is then applied. The interlayer adhesion of the coatings is improved by the inclusion of adhesion promoters. The Examiner states that such a multi-layer coating could be used for automotive refinishing.

Applicants respectfully submit that the teachings of the entire Anderson reference should be considered, and not just convenient portions, for an obviousness inquiry. Anderson's invention is directed to solving the problem of intercoat adhesion of various layers in a multi-layer coating. Applicants' invention is directed to solving an entirely different problem from that set forth by Anderson. As stated above, Anderson solved an interlayer adhesion problem. Applicants, on the other hand, address the problem of reducing solvent emissions of a refinish coating system. As is well-known, VOC (volatile organic content) of paints is regulated depending upon the paint usage. To reduce such emissions, water-based coating compositions can be used. However, when relatively thick water-based coatings are used for a basecoat layer (generally 40 microns and above), the resulting coating has a poor visual appearance. However, such higher thickness levels of basecoats are needed for coatings that have poor masking ability.

Applicants' solution to this problem is to use two basecoat layers, the first being a solvent-borne basecoat and the second a water-borne basecoat. When this combination of basecoats is top-coated with a lacquer clear-coating, a multi-layer finish is formed having an excellent appearance and superior physical properties. This is clearly illustrated in the Examples section of present application.[1] Example 1 shows a multi-layer coating formed according to the process of this invention utilizing a first solvent-borne basecoat layer and a second water-borne basecoat layer top-coated with a clear lacquer. Example 2 shows a multi-layer coating, but only with a water-borne basecoat and a clear lacquer top-coat. The Table on page 11 of Applicants' specification shows a comparison of the coated panels of Examples 1 and 2 wherein the appearance, gloss, flow, and hardness of Example 1 (the

[1] *See* pages 10-11 of the specification of the present application.

invention) are significantly better than the use of only a water-borne basecoat layer (Example 2), which is a surprising and unexpected result. The use of only water-borne basecoat instead of a combination of a solvent-borne and a water-borne (in comparable layer thicknesses) has disadvantages regarding e.g., topcoat quality and masking capacity. Especially the problem regarding masking capacity in a repair coating process is not mentioned in Anderson. Thus, Applicants have accomplished both a reduction of VOC and have improved the appearance and physical properties of the multi-layer finish with their claimed process. This certainly has not been taught or suggested by Anderson. Therefore, the second prong of the obviousness inquiry, outlined above, is not satisfied.

Further, in the Office Action, the Examiner has equated a primer and primer/surfacer to a basecoat. Applicants respectfully assert that a hypothetical person skilled in the pertinent art would not interpret a primer and/or a primer/surfacer as same as a basecoat. Primers or primer/surfacer and basecoats are distinct and serve entirely different purposes in a multi-layer coating system.

To further accentuate this point, Applicants have provided the following documents for the Examiner's review:

(1) Automotive Paints and Coatings, Edited by G. Fettis, VCH publication (1st Edition), pp 120-121, and

(2) Ullmann's Encyclopedia of Industrial Chemistry (5th Edition, Vol. A, pp 517-519).

In the Automotive Paints and Coatings document, various layers of a typical multi-layer automotive coating are set forth and identified. Fig. 5-1 pictorially shows the various layers and in particular, the primer layer, the primer/surfacer layer, the basecoat layer and topcoat layer. The primer/surfacer layer fills in voids and provides a smooth surface that can be sanded, if necessary. However, this layer does not provide color to the resulting multi-layer finish. As shown in Anderson, this is the gray layer. The basecoat layer is the color-providing layer of the multi-layer coating. The basecoat layer is not sanded or treated in any manner but is top-coated with a clear protective layer. Thus, each of the layers of a multi-layer coating have a special purpose and are significantly different from each other.

Similarly, Ullmann's Encyclopedia discusses multi-layer automotive paint coatings comprising primers, intermediate coats (also called fillers or surfacers) and

topcoats comprising a basecoat and a clear coat. This combination is the most popular topcoat used on automobiles today. The topcoat provides a full, deep gloss (wet look), high-brilliance metallic effects, long-lasting chemical and weathering resistance, and ease of polishing and repair. Thus, the purpose of a topcoat comprising a basecoat/clear coat combination is very different from that of the primer surfacer layer.

However, the Examiner, in the present Office Action (by virtue of incorporation of the Office Action of July 26, 2005) equates the gray solvent-borne primer to a basecoat. As pointed out previously, these are two different layers not functionally or structurally interchangeable.

Arguably, and although not actually supported by the Anderson reference, if the gray solvent-borne primer/surfacer were applied first as suggested by the Examiner, followed by the water-borne basecoat, a multi-layer composition of Example 2 of Applicants' specification would result. And to provide an adequate concealment of the gray solvent-borne primer/surfacer, an extra-thick coating of the water-borne basecoat would have to be applied. As shown in the comparative Example 2, this results in inferior appearance and physical properties of the multi-layer coating when compared to the invention that is set forth in Example 1. There is no teaching or suggestion in Anderson to provide for two layers of basecoat, the first, a pigmented solvent-based coating layer and the second, a water-based coating layer as required by the present Application. Thus, there is NO reasonable expectation of successfully producing the claimed invention via such a combination as suggested by the Examiner. The third prong of the obviousness inquiry is also not satisfied.

Therefore, the obviousness rejection based on Anderson can not stand and should be withdrawn and the claims allowed.

(II) U.S. PATENT NO. 6,592,999 TO ANDERSON, *ET AL.*, IN VIEW OF U.S. PATENT NO. 5,073,370 TO KUBITZA *ET AL.*, AND U.S. PATENT NO. 5,466,286 TO BRISELLI, *ET AL.*

Claims 4 and 5 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Anderson, in view of U.S. Patent No. 5,075,370 to Kubitza, *et al.* (*hereinafter* "Kubitza"), and U.S. Patent No. 5,466,286 to Briselli, *et al. (hereinafter* "Briselli"). Neither Kubitza nor Briselli, nor the combination of these patents make up for the many deficiencies of Anderson.

Specifically, the Examiner states that although Anderson fails to teach that the solvent-borne primer is a two-component coating composition, Kubitza teaches that "organic solvent based two-component polyurethane paints. . .are extensively used in the coating field." Therefore, according to her, "[i]t would have been obvious to one of ordinary skill in the art at the time the invention was made to have used organic solvent based two-component polyurethane paints. . .as solventborne two-component primer in Anderson. . ."

Applicants would like to point out that Applicants' Claims 4 and 5 are directed to basecoats <u>AND NOT TO</u> primers. Also, as pointed out *supra*, as understood by a person of ordinary skill in the pertinent art, a primer is distinct from a basecoat. And not only that. They also serve different functions. Primers are NOT basecoats and are not considered as interchangeable. Kubitza merely discloses that polyisocyanates can be used in coatings. Applicants' process for forming a multi-layer coating wherein the basecoat is a two-layer basecoat of (1) a solvent-borne basecoat, and (2) a water-borne basecoat, is not even mentioned. Applicants respectfully submit that combining Kubitza with Anderson is not relevant to Claims 4 and 5 of their invention. And to that end, Applicants respectfully disagree as to the alleged obviousness of their invention.

Similarly, Briselli shows a single water-borne basecoat being applied to a two-component polyurethane primer/surfacer. As pointed out previously, in the pertinent art, a primer is not a basecoat and <u>even a primer/surfacer is not a basecoat</u>. Therefore, all of the claim limitations are not taught in the references, i.e., prong I of obviousness inquiry not satisfied.

Secondly, the references do not provide any motivation to combine the references, and in fact such combination may not even be relevant. Finally, as pointed out *supra*, even if arguably such a combination were made (without any motivation or incentive to combine of course), such a combination will not have any reasonable expectation of success. Comparative Example 2 of the Applicants' disclosure bears testimony to this failure, in fact. Example 2 shows the inferior result both in appearance and in physical properties, when only one basecoat was used, as suggested by the Examiner.

Applicants respectfully submit that a *prima facie* case of obviousness is not established as a result. Therefore, the rejection based on the above combination of references can not stand and should be withdrawn and the claims allowed.

(III) U.S. PATENT NO. 6,592,999 TO ANDERSON, *ET AL.*, IN VIEW OF U.S. PATENT NO. 5,073,370 TO KUBITZA *ET AL.*, U.S. PATENT NO. 5,466,286 TO BRISELLI, *ET AL.* AND U.S. PATENT NO. 5,976,343 TO SCHLAAK

Claim 6 was rejected under 35 U.S.C. § 103(a) over Anderson, *supra*, in view of Kubitza, *supra*, Briselli, *supra* and U.S. Patent No. 5,976,343 to Schlaak (*hereinafter* "Schlaak"). The many deficiencies of Anderson, Kubitza and Briselli have been pointed out above and will not be repeated. As for Schlaak, it does not overcome the deficiencies of these references even if combined therewith, although no such combination is suggested by Schlaak.

Schlaak adds nothing to the teaching of the already cited patents. Schlaak merely states that primers can contain crosslinking agents and a variety of pigments and can be topcoated with water based color and/or effect-providing lacquers and that color-providing pigments can be used in these lacquers. There is no teaching or suggestion of Applicants' invention of using two basecoats, a solvent-borne basecoat and a water-borne basecoat, and finally coating with a clear lacquer to form a multi-layer coating. As discussed previously, this gives a significantly better appearance and physical properties in comparison to multi-layer coating that only uses a water-borne basecoat, as taught by Schlaak.

Therefore, again, as the *prima facie* case for obviousness is not established, the rejection of Claim 6 based on the above combination of references should be withdrawn and the claim allowed.

CONCLUSION

In view of the above remarks, Applicants respectfully submit that stated grounds of rejection have been properly traversed, accommodated, or rendered moot and that a complete response has been made to the Office Action mailed on December 20, 2005 and the Advisory Action mailed on February 27, 2005.

Therefore, Applicants believe that the application stands in condition for allowance with withdrawal of all grounds of rejection. A Notice of Allowance is respectfully solicited. If the Examiner has questions regarding the application or the contents of this response, the Examiner is invited to contact the undersigned at the number provided.

A one-month extension of time is hereby petitioned under 37 C.F.R. §1.136(a), and any fees required therefore are hereby authorized to be charged to our Deposit Account No. 04-1928 (E. I. du Pont de Nemours and Co.). Should there be a fee due which is not accounted for, please charge such fee to Deposit Account No. 04-1928.

Respectfully Submitted,

BY:

Date: April 20, 2006

Hilmar L. Fricke

HILMAR L. FRICKE, ESQUIRE
ATTORNEY FOR APPLICANTS
REGISTRATION NO.: 22,384
PHONE: 302-984-6058
FAX: 302-658-1192

BY:

Date: April 20, 2006

Rakesh H. Mehta

RAKESH H. MEHTA, ESQUIRE
ATTORNEY FOR APPLICANTS
REGISTRATION NO.: 50,224
PHONE: 302-984-6089
FAX: 302-658-1192

Automotive Paints and Coatings

Edited by Gordon Fettis

VCH Weinheim · New York · Basel · Cambridge · Tokyo

1995

Professor Gordon Fettis
Department of Chemistry
The University of York
Heslington
York YO1 5DD
United Kingdom

1st edition 1995

Published jointly by
VCH Verlagsgesellschaft, Weinheim (Federal Republic of Germany)
VCH Publishers, New York, NY (USA)

Editorial Director: Dr. Barbara Böck, Louise Elsam
Production Manager: Dipl. Wirt.-Ing. (FH) Bernd Riedel

Library of Congress Card No. applied for.

A catalogue record for this book is available from the British Library

Die Deutsche Bibliothek – CIP-Einheitsaufnahme

Automotive paints and coatings / ed. by Gordon Fettis. –
Weinheim ; New York ; Basel ; Cambridge ; Tokyo : VCH, 1995
ISBN 3-527-28637-3
NE: Fettis, Gordon [Hrsg.]

Printed on acid-free and low-chlorine paper

Composition: Mitterweger Werksatz GmbH, D-68723 Plankstadt
Printing: Strauss Offsetdruck, D-69509 Mörlenbach
Bookbinding: Wilh. Osswald & Co, D-67408 Neustadt
Printed in the Federal Republic of Germany.

5 Topcoats for the Automotive Industry

U. Poth

5.1 Definitions

Topcoats have as their main target to provide stability of the coating system against mechanical and chemical attack and to build an appealing effect. To fulfill all these aims, topcoats can consist of different layers. Whereas the traditional, so called solid colour topcoats consists of only one layer, today most of the metallic topcoats consist of two layers, the metallic basecoat and a clearcoat. Based on the experience with this two-layer system, there is a trend to apply solid colour topcoat systems in two layers as well. For special high quality topcoat systems there is the use of a solid colour precoat, which is applied before the topcoat to provide optimum smoothness and colour appearance. Usually, for the application of automotive coating systems there are three stoving processes: for the primer, the primer surfacer and the topcoat system. In the case of using a solid colour precoat four stoving times are required.

While the layer of primers for automotive coatings have a thickness of 18–23 μm (0.71–0.91 mils), the layer of primer surfacers have approx. 35 μm (1.38 mils), the solid colour topcoats have ca. 40 μm (1.57 mils), the metallic basecoats have 12–15 μm (0.47–0.59 mils) and the clearcoats have approx. 40 μm (1.57 mils), see Figure 5.1 [5.1].

Repair coats [5.2] are used for cars after any damage to the car body or in the case when an old coating system is no longer good in appearance or resistance. Repair coating systems consist of primers, primer surfacers, topcoats (in the special meaning of solid colour topcoats), basecoats and clearcoats ('after market repair'). The main difference between the OEM systems and the repair coats is the application method and more specifically the film building conditions. While the OEM topcoats will be stoved after spray application in tunnel ovens at temperatures of 120–150 °C (248–302 F) to build films with optimum properties, repair topcoats have to build resistant coat films at ambient temperatures or possibly at temperatures up to 60 °C (140 F). Therefore, the contents of repair coats are different to those of OEM coat systems.

If this damaging occurs during the coating process in the application line, the quality controller in the car plant can decide to run a repair coat application for a small part of the car or for the total car body. In the latter case the repair coat application will run under the same conditions as in the first coating process ('high-bake-repair' on line)

If any damage to the coated car body is observed in a later state of the car construction and it is necessary to repair the coating system, the application of a repair coat runs always at temperatures about 80–90 °C (176–194 F). For this so called 'low-bake-repair' a special coating system has to be used.

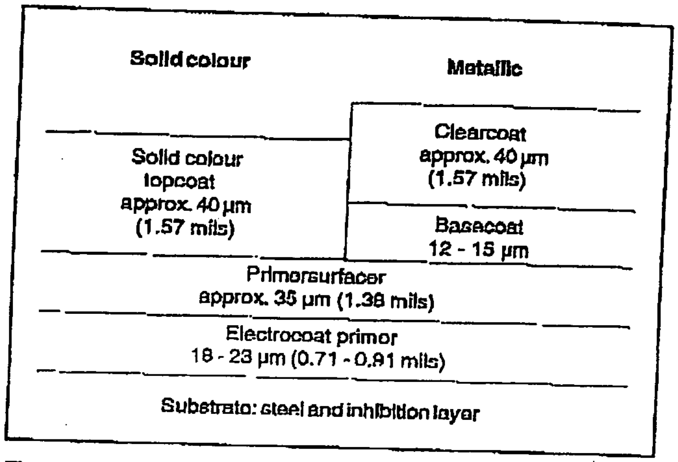

Figure 5-1. Layers of automotive coating systems.

Additionally there is an increase of the use of plastic parts in the construction of car bodies.

Coatings for plastic parts are quite different from those for the steel parts of a car body (see Chapter 6). Plastic parts can not be heated to higher temperature without loss of properties. Therefore topcoats for these parts are applied separately from the car body and the conditions of film building are at lower temperatures, normally 60–80 °C (140–176 F) in some special cases higher (max. 120 °C, 250 F) [5.3]. Therefore topcoats for plastic parts are related to repair topcoats, but one has to achieve a much higher flexibility for this type of topcoat.

5.2 The Development of the Different Automotive Topcoat Systems [5.4] (see Chapter 1)

The coating materials of the first cars consisted of air drying binder systems based on vegetable oils and resins: rosin and copals. Copals are semifossil rosins of trees which grew in the tropics [5.5]. In England, this coating technology, based on the combination of vegetable oils and copals in a hot blend process, was developed to a high quality. For the coating process 20 separately painted coat layers are required and up to 3 weeks work time. In the twenties the demand for automotive cars increased rapidly and production assembly lines were invented and developed. Topcoats based on cellulose nitrate as a film building vehicle were used. Cellulose nitrate was combined with plasticisers, and the coating systems which consisted of this combination performed fast drying at ambient conditions and had good appearance [5.6].

Ullmann's Encyclopedia of Industrial Chemistry

Fifth, Completely Revised Edition

Volume A 18:
Nucleic acids to Parasympatholytics and
Parasympathomimetics

Editors: Barbara Elvers, Stephen Hawkins, Gail Schulz

VCH

1991

Production Director: Maximilian Montkowski
Production Manager: Myriam Nothacker

Editorial Assistants: Ilse Bodrich, Helen Goltz, Reinhilde Gutsche, Monika Pikart-Müller, Philomena Ryan-Bugler

Library of Congress Card No. 84-25-829
Deutsche Bibliothek, Cataloguing-in-Publication Data:
Ullmann's encyclopedia of industrial chemistry / ed.: Barbara Elvers ... [Ed. advisory board Hans-Jürgen Arpe ...]. — Weinheim ; Basel (Switzerland) ; Cambridge ; New York, NY : VCH.
Teilw. executive ed.: Wolfgang Gerhartz
Bis 4. Aufl. u. d. T.: Ullmanns Encyklopädie der technischen Chemie
NE: Gerhartz, Wolfgang [Hrsg.]; Elvers, Barbara [Hrsg.]: Encyclopedia of industrial chemistry
Vol. A. Alphabetically arranged articles.
18. Nucleic acids to parasympatholytics and parasympathomimetics. – 5., completely rev. ed. – 1991
ISBN 3-527-20118-1 (Weinheim ...)
ISBN 0-89573-168-1 (New York)

British Library Cataloguing in Publication Data
Ullmann's encyclopedia of industrial chemistry.
18. Nucleic acids to parasympatholytics and parasympathomimetics
1. Industrial chemistry
I. Elvers, Barbara II. Rounsaville, James F. III. Schulz, Gail
661
ISBN 3-527-20118-1

Printed on acid-free paper

Distribution
VCH Verlagsgesellschaft, P.O. Box 10 11 61, D-6940 Weinheim (Federal Republic of Germany)
Switzerland: VCH Verlags-AG, P.O. Box, CH-4020 Basel (Switzerland)
Great Britain and Ireland: VCH Publishers (UK) Ltd., 8 Wellington Court, Wellington Street, Cambridge CB1 1HZ (Great Britain)
USA and Canada: VCH Publishers, Suite 909, 220 East 23rd Street, New York NY 10010-4606 (USA)

Cover design: Wolfgang Schmidt
Composition, printing, and bookbinding: Graphischer Betrieb Konrad Triltsch, D-8700 Würzburg
Printed in the Federal Republic of Germany

and second primers prevent corrosion of the metal surface. The pigments and extenders allow the primers to react with ions (Cl^- and SO_4^{2-}) that diffuse into the film from the atmosphere. The pigmented organic film also forms a barrier against humidity that may otherwise initiate a corrosive process.

Heavy-metal pigments (mainly lead pigments) and zinc chromates were used succesfully in earlier decades. These pigments are now being replaced by nontoxic pigments (see Section 11.3.1, and → Pigments Inorganic).

The first and second topcoats build up the necessary dry film thickness and protect the entire coated construction against the adverse influence of the atmosphere.

Binders based on linseed oil and other oils have been used for many years in anticorrosive primers. Alkyd binders, especially those with high fatty acid contents, perform similarly. The main disadvantages of these binders is their limited chemical resistance and their slow drying.

Chlorinated rubber and poly(vinyl chloride) (PVC) resins allow the formulation of coatings with good chemical resistance. They are therefore used for steel constructions in chemical plants. Since they are not resistant to many organic solvents, they should not be used in oil refineries or plants handling solvents. The undesirable fact that these binders contain halogens in high amounts is responsible for their decreasing use. Overspray of chlorinated rubber and PVC paints and contaminated blasting materials produced after removing old paint cause severe problems in waste incineration plants (generation of hydrochloric acid), as well as in waste disposal areas (pollution of soil and water).

Epoxy resins cured with aminoamide resins or amine adducts are often used for large metal constructions. Paints based on these resins are normally applied in four layers. Epoxy coatings form films that are resistant to organic solvents and a wide range of chemicals. Epoxy coatings are currently used for the majority of steel and aluminum constructions, but are also suitable for use on other construction materials (e.g., concrete). They can protect buildings in chemical plants and nuclear power plants. Epoxy coatings are less susceptible to deterioration by radiation than other organic films, and are also resistant to decontaminating chemicals (usually aqueous detergent solutions) used to remove radioactive dust from walls and other surfaces in nuclear power plants.

Heat-resistant coatings have silicone-resin binders. Pigments for such paints are zinc dust, flakes of aluminum or stainless steel, titanium dioxide, or silicon carbide. Such paints can withstand temperatures up to 600 °C.

Paints with inorganic binders are also used for corrosion protection of steel constructions. These paints are based on organic silicates which are soluble in mixtures of alcohols or other water-miscible solvents (see Section 2.15.2). Ethyl silicate is often used and mostly pigmented with zinc dust. Zinc-rich primers and single coats are available as one- or two-pack products. Zinc-rich ethyl silicate paints dry to form inorganic films that are very durable even under adverse atmospheric conditions, (e.g., onshore and at sea). These coatings have excellent resistance to oil, solvents, and mechanical impact, and are therefore used on drilling stations, oil rigs, and ships. Since zinc-rich silicate coatings are heat resistant, they are also used in hot areas of iron works, coal mines, and coking plants.

Heavy-duty coatings are often still applied manually with brushes or rollers that completely wet the metal surface; holes and pores are filled with paint. This is especially important when old, partially rusted constructions are repainted after sanding. Brushing and rolling, however, only allow a slow working speed. Larger surface areas must be painted with airless spraying equipment.

11.2. Automotive Paints

11.2.1. Car Body Paints

Cars are coated to achieve maximum, long-lasting corrosion resistance. Cars must also be given an optimum appearance that lasts for many years. Long-lasting color and gloss retention as well as resistance against cracking (especially in clearcoats of two-coat metallics) are therefore necessary. Topcoats of automobiles must withstand solar radiation and atmospheric pollution (e.g., acid rain and soot from oil combustion). Aggressive chemicals (e.g., road salts and cleaning agents containing detergents) can damage the coating if they come into contact with the car surface. Furthermore, small stones cause heavy impact on automobile surfaces and corrosion via chipping.

Large numbers of cars are manufactured on fast-running assembly lines. The paints must

therefore be applied with highly efficient equipment, and must dry very quickly. The paint products are classified as primers, intermediate coats (also called fillers or surfacers), and topcoats (or finish). The primers and fillers are designated as the undercoating system.

Car paints are cured with heat in special oven lines. Electrodeposition coatings (used as anticorrosive primers) contain only small amounts of volatile organic compounds (VOC), whereas intermediate and topcoats release considerable amounts of VOCs. Intermediate coats based on waterborne resins have been developed to decrease VOC emission and are already being used in some automotive plants. Basecoats, as part of base–clear topcoat systems, contain very high amounts of volatile organic solvents. Waterborne basecoats were developed more recently to lower this source of solvent emission. Some car manufacturers are operating pilot lines with the aim of introducing waterborne basecoats into their production processes. Many car producers in the United States and Europe have already switched their topcoat lines over to waterborne basecoats [11.3].

Pretreatment. Various metals are used for manufacturing car body shells: steel, galvanized steel, aluminum alloys, and zinc-rich precoated steel. The surfaces of these metals are routinely contaminated with oils, drawing lubricants, dirt, and assembly residues (e.g., welding fumes). The body shells are pretreated to remove these contaminants and to obtain a well-defined, homogeneous surface that has the necessary properties for adhesion of primers. Pretreatment includes surface cleaning and formation of a phosphate conversion coat on the shell surface (see Section 8.2.1); six to nine discrete steps are involved using either spraying devices or baths. Continuous control of phosphating solutions ensures good results [11.1], [11.4].

Anticorrosive Primers. Anticorrosive primers are applied in dip tanks so that they reach all parts of the car body; dipping is a fast method of application. The standard method for application of primers is electrodeposition. Anodic electrodeposition paints were used when the electrocoating technique was first applied, but cathodic electrodeposition is now predominant because it provides better corrosion protection.

The binders for cathodic electrodeposition are epoxy resin combinations dispersed in water (see Section 3.8). Advantages of anticorrosive electrocoatings include excellent corrosion resistance at a dry film thickness of ca. 20–30 µm. Electrocoats are stoved at 165–185 °C to obtain films with the desired properties. The paint industry is now developing electrocoats that can be cured at lower temperatures (140–150 °C). Electrocoating produces a homogeneous film that covers the entire car body surface, including recesses and cavities.

Although the dry film thickness on the metal edges is somewhat lower, these areas are still efficiently protected against corrosion. The ultrafiltration technique results in a very high transfer effect and a uniform coating: paint solids from the bath are deposited on the metal surface without loss. Since electrodeposition paints have a low organic solvent content, air pollution is low. The dip tank contents are not flammable, which reduces insurance costs [11.5].

Intermediate Coats. Intermediate coats (fillers) are applied between the anticorrosive primers and the topcoat systems. They provide good filling and flowing layers which are normally smoothed by sanding. Oil-free polyesters are used as binders for fillers. They react with blocked isocyanates in 20 min at 165 °C. Their high flexibility gives the whole coating system a highly effective mechanical (stone chip) resistance.

Fillers are applied with electrostatic spraying devices (fast-rotating bells) to give dry film thicknesses of about 40 µm. Waterborne fillers with polyester–melamine binders (primer surfacers) have been developed to reduce the volatile organic content. They yield a film thickness of 30 µm after a prereaction time of 10 min at 100 °C and a reaction time of 20 min at 165 °C. The properties of the films are similar to those formed by solventborne paints. More recently, waterborne fillers based on blocked isocyanates have been developed. Field trials have shown that their mechanical resistance is very good.

Topcoat Systems. Topcoats form an important part of the protection system of the car body surface, but are much more important for decoration. The basic requirements for a car topcoat are:

1) Full, deep gloss (wet-look)
2) Highly brilliant metallic effects
3) Long-lasting resistance against weather and chemical influences
4) Easy to polish and repair

Topcoats based on nitrocellulose combinations with plasticizers and alkyd resins were used in the first decades of industrial car manufacturing. These were followed by thermosetting alkyd–melamine combinations, and later by thermosetting acrylics. The use of stoving enamels as thermosetting paints also accelerated production significantly. Although the properties of these coatings during application and in use were very good, their high content of volatile organic solvents had to be lowered to comply with legal restrictions.

The basecoat–clearcoat system is presently the most commonly used type of topcoat for cars because it is the standard application system for metallic colors. Today, about 70% of all cars have metallic topcoats. The basecoat–clearcoat system consists of a colored layer (basecoat) which is overcoated after a short flash-off time with a protective layer of clearcoat. Both coats are cured together at 120–140 °C. The basecoat contains pigments which provide two types of finish: solid (straight) colors or metallic.

Solventborne metallic basecoats contain ca. 15% solids and ca. 85% volatile organic solvents. These solvents are not released into the atmosphere, but are converted to combustion gases in afterburners. To reduce emission of organic solvents from this source, waterborne basecoats have been developed.

Waterborne basecoats with higher solids contents are now available: metallic basecoats contain about 18 wt% solids and solid (straight) color basecoats 25–40 wt%. The solvent in waterborne paints is not pure water; about 15% of organic solvents is still needed as a cosolvent for proper film formation. Metallic basecoats are applied at a DFT of 15 μm, solid color basecoats at a DFT of 20–25 μm.

Basecoats are sprayed in two layers. The first layer is sprayed electrostatically with high-speed rotation bells, the second layer is sprayed with compressed air to achieve proper orientation of the aluminum particles in metallic paints. The basecoat is then dried for 3–5 min in a warm air zone at 40–60 °C.

A final layer of clearcoat is applied with electrostatic high-speed rotation bells [11.3], [11.7] to protect the system against atmospheric influences, including wear and tear during use.

Alkyd–melamine clearcoats with an approximate solids content of 50% contain UV-absorbing agents to prevent deterioration in extreme climates.

Some car manufacturers use clearcoats with acrylic binders that are cured with aliphatic isocyanates. Their chemical and mechanical properties are better than those of alkyd–melamine clearcoats. Solid contents are as high as 58%.

Car Repair Paints [11.1]. Repair paints are used in considerable amounts for refinishing cars. Since repair shops cannot provide the same facilities as those of car manufacturers, repair paints are dried at ambient temperature or elevated temperature up to 80 °C (metal temperature). Alkyd repair paints and nitrocellulose paints were standard materials, but two-pack acrylate–isocyanate refinish paints are now more common. Their properties are similar to those of the original car coatings (long-lasting gloss and color, mechanical and fuel resistance). Car refinish paints are available in a wide range of colors, solids as well as metallics. They are often supplied to shops and retailers as mixing schemes.

Paint systems for car repair comprise anticorrosive primers, putties, intermediate coats, and topcoats; repair coatings applied to refinished cars have similar durabilities to those of the originally manufactured coating systems.

11.2.2. Other Automotive Coatings

The properties of coating systems used for car components differ considerably from those of systems used for exterior car surfaces. Color is not important (and is mainly black or gray), but anticorrosive properties similar to those of car body coatings are required. Since car components are produced in large numbers, coatings are commonly baked at high temperature to ensure a high reaction rate and rapid film formation.

Wheels are electrocoated; engine blocks are coated with heat-resistant, usually waterborne materials. Other parts (e.g., steering equipment and shock absorbers) are painted with two-pack, one-coat epoxy systems that are usually solventborne; use of waterborne systems is, however, increasing.